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SITE: Barite Hill
BREAK: 2.1
OTHER:

**From:** Leo Francendese/R4/USEPA/US
**To:** Loften Carr/R4/USEPA/US@EPA
**cc:** Jim McGuire/R4/USEPA/US@EPA

**Date:** Thursday, September 06, 2007 04:12PM
**Subject:** Response to Remedial Comments for Proposed Barite Hill Removal Action

Loften,

Appreciate the comments and ability to resolve them before the meeting at Ridgeway.
Let me know were you stand in your support of the action.

Thanks
Leo

Attachments:

Barite Hill bullets_ed3.doc

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**Removal Program Response to Remedial Program Comments Concerning the Proposed Removal Action at Barite Hill Mine September 6th, 2007**

**Consistent with the NCP, the Removal Program strives to conduct actions that do not interfere with potential future remedial actions. While we realize that some of the comments below extend beyond the focus of concern for this potential for interference, we have taken the opportunity to offer further technical updates on our findings and thought process. The Removal Program looks forward to the Remedial Program's continued technical expertise in the execution of the proposed actions and its added value in decision making.**

**The following responses were written with the assistance of the US Bureau of Reclamation/Department of Interior.**

Comments on the Proposed Removal Action / Pit Mitigation at Barite Hill Mine, McCormick, South Carolina, September 5, 2007

1. The suggested interim action makes assumptions concerning the sources of acidity to the pit -- 80% from waste rock pile, 10% from exposed pit walls, and 10% from iron cycling. What are these assumptions based on?

**Response:**

**They are only professional estimates based on historical knowledge concerning other similar pyrite based mining sites and the incorporation of observations from the initial Barite Hill Site Inventory Report conducted by the US Bureau of Reclamation/Department of Interior. The intent of the ratios is to give a sense of proportion of the current conditions. Knowing the exact proportions does not add to the value of the decisions.**

2. The lack of water balance information is a major limitation to this review at this point. The remedy is based on direct precipitation and surface run-off being the only sources of inflow into the pit.

**Response:**

**We have mentioned a gw component as also being an inflow source. Historical aerial photography demonstrates that the pit is filling up. The implication in the question is that there is no separation in knowledge between gw and surface water that fills up the pit. Nonetheless it is irrelevant whether the pit is filling up with gw or surface water. Even after the removal action we expect the pit will both overflow and continue to seep. We expect this released water to be of significant improved quality after the proposed actions.**

How likely is that to be the case?

**We believe that there is an unknown but small gw component. Again we see this on other similar sites. At the end of mining, the gw inflow rate is at its peak due to the head differential between the gw table and the pit water level which was kept pumped out during the mining operation. When pumping stops, the pit fills from a combination of sources (precipitation, runoff, and gw). The head differential and**

**resulting gw inflow rate diminishes over time, eventually equilibrium will be reached. We also known from the mine permitting at the site, the aquifer yield was fairly tight. We don't have reason to suspect that a giant open flow system exists.**

Are these sources sufficient to cause overtopping in a few years (assuming no major storm event)? Or is groundwater a potential or known source of inflow? Could run-on diversions be used to reduce the amount of water that runs into the pit?

**Response:**

**Because the pit sits on a mound (originally an igneous intrusion), the primary contributing watershed is the 10 acres where the exposed pyrite is located. Reshaping the 10-acres for diversion to prevent surface water runoff into the pit was considered and ruled out. The topography is such that a diversion of runoff away from the pit would require a deep excavation at considerable expense which would require blasting to expose and rubbleize more pyrite-rich bedrock thus creating another continuous source of release. Therefore, surface water diversion is not a viable option.**

3. The pH of an estimated 100,000,000 gallons of water in the pit are reported to have decreased from about 11 in July 1997 to about 2.0 to 2.2 by November 2003 and as low as -3.9 in 2006. Have calculations been made that demonstrate that run-off from a 50,000 cubic-yard pile of waste rock could account for that much acidity?

**Response:**

**This is a misunderstanding. The pit did not contain 100,000,000 gallons at the time of previous pit neutralization. A much smaller body of water was neutralized which represented 2.5 years of inflow. Over time (almost 13 years) the pit lake has gotten bigger and bigger and as the water rises and the runoff accumulates the volume of water accumulates with newly fed acid water likely overwhelming any alkalinity or buffering capability that existed.**

**Update ... the most recent (Sept 2007) field sampling results indicate pit pHs near 2.0 at surface and depth. There has been a significant period of drought from the last field measurement. While analytical error is always a possibility it should also be noted that the prior field sampling event which documented the -3.9 pH took place shortly after a significant rainfall and was located next to the 10 acre watershed. It is possible a singular slug of acid release occurred after this rainfall event.**

4. M.J. Gobla's white paper ("Pit Lake Formation and Mitigation") mentions (under option 4) an "ongoing release of selenium" from spent ore in the Heap Leach Pad and the landfill. This is given as the reason these materials should not be backfilled into the pit. Does the waste rock contain significantly less Se than the spent ore?

**Response:**

**In other similar sites we don't endorse the concept of backfilling spent ore into the pit because the existing remnants of the cyanide solution do promote the**

**overall pit. Characterization of the pit to confirm water depths and to identify variation of the pit lake chemistry with depth (profiling) is underway to verify the initial reports from the State. That said, water quality is a concern.**

**Assuming additional lime, similar to the slaked lime currently stockpiled at the site, is brought in and used for neutralization, the result will be a neutralized pit lake having an initial pH of in the range of 9 to 11 standard units. At the mixing tank, the lime addition will likely result in an initial pH of about 11. Although this will drop out most of the metals like iron, aluminum, copper, and zinc, it is likely that compliance with all stream discharge standards will not be met. The comment is correct about little reduction in selenium values from lime precipitation. Also, cadmium is often another metal that is difficult to reduce to compliance levels because the standards are so low. Such compliance is often difficult to achieve even with a conventional lime water treatment plant where the reagent addition, pH of the reactions, settling, and clarification are carefully controlled. Although we await results from chemical profiling of the pit, we anticipate very high levels of sulfate and TDS, only a part of this will be taken out by the lime neutralization process. Considering that several hundred feet of the stream have already been killed off by acid seepage, a temporary release of alkaline water should not have a significant long-term impact to the acidified stream or the receiving lake. Indeed, the State is supportive of less stringent discharge criteria if necessary during the removal operations in order to conduct the source removals.**

8. When the pit fills to the spillway, there would presumably be a continual discharge (with increases after every precipitation event.) Will there be an evaluation of the potential impacts of these discharges on receiving waters downstream to Strom Thurmond Lake?

**Response:**

**The current situation is that large slugs of acid water will soon be discharging to receiving waters if nothing is done. If neutralization and carbon loading are successful, there will not be any significant downstream impacts. The plan requires that monitoring and very infrequent lime and or carbon additions would be continued indefinitely into the future to maintain good water quality in the discharge. Under post removal site controls, the State will likely continue monitoring the downstream conditions of the receiving waters and is the most likely candidate to continue the very infrequent lime and or carbon additions to the pit.**

9. Placing 50,000 cubic yards of waste rock into the pit would be (more-or-less) irreversible. It may be appropriate to consider a temporary action to reduce water and/or oxygen infiltration into the waste rock such as temporary encapsulation / isolation of the waste rock pile under a relatively impermeable cover, application of bactericides to slow microbial oxidation, or placement of a chemical cap to reduce infiltration.

**Response:**

**continued release of selenium. The waste rock tends to be less mineralized than the ore, but the primary part of the equation is that we haven't activated the selenium release potential by soaking the rock with cyanide solution.**

5. Will placing the waste rock into water with pH of -3.9 dissolve even more metals than are now mobilized by precipitation infiltration, and thus make the water quality of the pit water even worse than it is today? How much additional uncertainty does this add to the expected lime needs?

**Response:**

**Adding the waste rock will result in a single flushing out of the stored acid-metals salts from the waste. This single event will have only a small negative affect upon the pit chemistry due to the large size of the reservoir. Each time there is a soaking rain a similar flush of the stored acid-metal salts occurs and the resulting runoff flows down into the pit. Under the proposed plan there will only be one more flush of acid salts, instead of the multiple flushes which are occurring each year in response to precipitation events. One more flush will not significantly change the lime requirements.**

6. How much lime will it take to neutralize 100,000,000 gallons of water with a pH of -3.9? Is the range of costs for neutralization ($300,000 to $1,000,000) based on possible ranges of pH within the pit, ranges of mixing efficiencies that can be achieved, different treatment endpoints, or other variables?

**Response:**

**Sampling and testing of the pit water, and gathering information about available lime sources is ongoing at this time. The wide range of estimated costs reflects the uncertainty due to the current lack of information regarding the amount of acid to be neutralized, the efficiency of the lime product that will be used, and the possibility of having to create passive drying beds for excess sludge. We plan on conducting a titration with actual pit water to evaluate likely lime requirements.**

7. Based on sample BH-004-SW presented in the PA/SI (this sample was taken at a time when the pit was described as having a pH of about 2), treatment to 99% metals reductions would result in water with concentrations of aluminum, cadmium, copper, and zinc that are likely to significantly exceed SC water quality criteria. Treatment efficiencies of this magnitude would likely not be realized for all metals and certainly would be difficult to achieve for metals such as cobalt, manganese, and zinc, which require pH of 8 or higher for efficient removal. Other metals, such as selenium, are also difficult to remove by lime dosing. What metals values will SCDHEC require in order to allow discharge of the upper 10 feet of the water column? Will they place limits on sulfate, hardness, TDS, and TSS? Can these limits be achieved? Will they permit a mixing zone in the unnamed tributary receiving stream?

**Response:**

**Since the pit water was not sampled at different depths, it is difficult to rely on results from past grab sample events as being characteristic of the nature of the**

**The key is to change conditions to bring acid generation to a snail's pace so the lake can be easily managed. The current most cost effective method of getting the waste into deep water will require dumping off of the pit access ramp, We intend to do soundings to verify the depth of water in the chosen location, and monitor the placement. Additional methods such as conveyor belt movement of material will be considered as necessary.**

11. Are there material handling concerns with regard to oxidative heat within the pile? Could it potentially combust spontaneously when interior portions of the pile are exposed to the atmosphere (as is the case with mineral concentrates from hard rock mining sites)?

**Response:**

**No, but this is a common question asked about reclamation at acid sites. First it should be understood that there is not one single large pile, the waste is spread out over the 10 acres in numerous individual piles that were dumped at random. It is true that some fine-grained sulfide concentrates have a tendency to catch on fire, but this is very rare with acid generating mine waste. Some acid mine sites develop steam vents in the winter when air flow through the waste rock piles are at their greatest flow rates due to thermal convection. The higher the pile, and the greater the pyrite content, the more prevalent this is. For example, at the 400-foot-tall Ruby Waste Dump at the Gilt Edge Mine we observed active steam vents just prior to the geomembrane capping project and the State of South Dakota became concerned that it could degrade the geomembrane. These vents went away as soon as seasonal temperatures warmed up, and our excavation and shaping of the waste did not reactivate the steam vents. The Golden Sunlight Mine in Montana is one of the few mines where they have had the pyrite-rich waste-rock dumps catch on fire, but again only during cold winter days and only in very tall dumps where convection put a lot of air flow through the waste allowing heat to build up over time to ignition temperatures. Those fires are typically extinguished by excavation and watering to dissipate the heat, watering alone is usually not effective in putting them out. At Barite Hill we do not anticipate internal combustion problems for several reasons. The waste-rock fines at Barite Hill are not pure sulfides like a mineral concentrate, they are a mixture of pyrite with inert minerals like barite and quartz. The piles are not tall so convection is not a problem, and excavation of such low piles is likely to dissipate built up internal heat rather than add to it. The existing waste piles are so small and thin that they are essentially bathed in oxygen rich air in their present state, excavation will only accelerate oxidation a little over current conditions and for a small amount of time.**

12. At what depth does the pit become anoxic and sufficiently low in ferric iron that continued oxidation of the waste rock would be limited? Would the backfilled waste rock be entirely in that zone? Would the backfilling operation upset this interface?

**Response:**

**Typically anoxic conditions are seen within 6 to 20 feet of depth, our target for waste placement is 30 feet or more of water cover. Also, we want to place the**

Such temporary measures are a waste of precious project money, they delay getting the job done and increase the overall cost, what is the point of waiting? One should only expend funds that contribute to a long-term solution. Either one puts the waste into the pit or builds a robust permanent repository. Pit volumes willing (current estimates are a minimum of 32 feet water using current drought conditions and 52 feet allowing for 10 to 15 feet of pit freeboard ... these volume estimates will be verified in further pit scopings), the state of the practice is to put the waste into the water where it will join the tens of thousands of cubic yards of similar pyrite-rich waste-rock rubble that are already under water and be done with it. Should pit volumes be unacceptable for a subaqueous cap, the alternative of a robust repository is currently beyond the resources of the removal program.

According to the NCP, removals should be consistent with future remedial actions within the scope of the removal. Part of that consistency is a preference for permanent solutions. As a last option, the removal program will consider cost effective "covers/caps" to buy time for other programs, such as remedial to raise the money for potential remedies such as a robust permanent repository. Site history of remediation techniques by the prior operator reflects a failed attempt at using a chemical material to cover the waste rock.

The currently understood status of the NPL Listing is that while the Site has the potential to list, it sits low on the tiering scale due to its listing criteria thereby minimizing the likelihood of funding. The State is poignantly aware of this issue and therefore highly motivated to support a substantive, permanent removal action of the major acidification sources at the site.

10. If 50,000 cubic yards of waste rock is placed in the pit, would it be appropriate to amend the material with lime or other neutralizing agents prior to placement? How will this be achieved? How will the material be placed to ensure that it gets to the desired depth within the pit?

**Response:**

Trying to do this is currently under consideration but is difficult to implement. The conventional method would be to screen out the large boulders and then mix the remaining undersize waste with lime prior to backfilling into the pit. This procedure unfortunately more than doubles the cost of mitigating the waste due to the multiple handling operations required to separate the boulders and perform the mixing of lime with the finer fraction. Part of the interest in next week's visit to Ridgeway is to ascertain cost saving methods of execution and to establish networking that would encourage the opportunity for both technology transfer and discounted pricing for materials and supplies within the mining community.

One method currently being evaluated would be to soak the waste with a lime slurry while it is being excavated and moved into the pit. This would neutralize the current acidity but would also mean delaying placement of the waste until the pit lake was neutralized so it is not dumped into acid water.

Either method of neutralization would only eliminate the present acidity, not future acid potential. It is not likely that sufficient lime would remain in the waste once dumped into the water to sequester future acid potential.

**Copper, Berkeley Pit, Sleeper and other acid sites is that despite all of the extensive characterization and treatability studies, the actual mitigation efforts did not go exactly as planned. When doing things at full scale it must be guided by professional judgment and results must be evaluated. At Gilt Edge the patented liquid carbon loading did not work until we convinced EPA to add wood chips to the mix to create needed surface area for the bacteria to thrive. At Sleeper, despite the huge amount of money spent by the mining company characterizing the pit walls and waste backfill they underestimated the amount of stored acidity that was released. Additional lime solved the problem, as it did a few years later when Sleeper experienced a massive slope failure. The worst results we have seen in our own projects and in those of others is that it has taken more lime, more carbon, and/or more time to deal with the problem, this is a small risk to take. We are not aware of a single mine where actions had to be undone in the process of establishing a viable pit lake.**

**We acknowledge that there is little experience with negative pH water, but the laws of chemistry do not change because the water is more acid than normally encountered. This will require more lime. We intend to run treatability tests with pit water to determine the required liming rates and resultant sludge volumes and water chemistry. It should be recognized that such tests are only a guide, actual results are always less efficient that the test results would indicate.**

14. There should be geotechnical studies completed prior to design and construction of the spillway to ensure the structure will be permanent and that water conveyed across the spillway will be routed to Hawes Creek without unexpected erosion, channel overtopping, or other consequences downstream. What storm event will the spillway and downstream channel be sized to hold?

**Response:**

**We agree, it is essential that a stable spillway be established. There is a strong possibility that after the loose soil and weathered rock is removed that the underlying material may need to be strengthened by methods such as grouting prior to construction of a spillway crest. The spillway designs have not yet been funded or initiated. We typically design a dam for something between the 10,000 year flood and the PMF but for a mine where loss of life is not a concern a 100-year event is normally used for design with consideration of what larger events would do. It is envisioned that the spillway would have capacity to safely pass much larger events, but some erosion damage to the downstream area would be expected.**

**waste prior to neutralization so a layer of low permeability sludge will cover the waste.**

**The current depth of anoxic water is not known, we are gathering this data for the existing pit and expect it to be rather shallow, but things will change. Anoxic conditions depend upon specific circumstances of the individual pit, and change over time. It is the long-term condition of the pit after mitigation which matters, not what the acid pit is doing at the moment. Once full of water to the overflow point, most pit lakes show anoxic conditions within 6 to 20 feet in depth (rarely deeper), there is also a chemical stratification due to TDS and other constituents in the water, and they do not turn over. The variation in depth and time required to reaching anoxic conditions is influenced by a number of factors which include:**

- **Wind turbulence – large pits are stirred up by the wind more than small ones thus causing deeper mixing of the oxygen rich surface waters with the deeper anoxic zones.**
- **Carbon content – organic carbon in the water will consume oxygen through bacterial action.**
- **Sulfide oxidation – pyrite exposures in contact with the water will rapidly consume oxygen to form acid and can result in a shallow aerobic zone**
- **Flow rates – inflow and outflow of water can affect the depth of the aerobic zone.**
- **Salinity and TDS which promote stratification and prevents turnover**

**Addition of the waste rock will not upset the anaerobic zone in the pit, this is the wrong question. It is the neutralization of the water that will upset the existing stratification of the pit and eliminate the anoxic conditions. The lime must be mixed with the water which will add a lot of oxygen. The pit is so acid that a large amount of water must be treated to effect neutralization and we anticipate that most if not all of the pit will become oxygenated. Although this will occur, stratification and re-establishment of anoxic conditions can be achieved in one to two years time. Acid production will never be completely eliminated at this pit principally because treatment of the steep pyrite bearing highwalls above the water table will be imperfect, therefore carbon loading of the water is also necessary to establish a sulfate reducing bacteria zone in the pit that can generate alkalinity and counteract the continued (but reduced volume of) acid inflow.**

13. There are several significant differences between Barite Hill and Gilt Edge, Sleeper, and other mine pits where comparable remedies have reported success. For example, there was extensive treatability testing at these other mines, which is not presented in the information provided. In addition, Barite Hill's negative pH is orders of magnitude more acidic than the other pit lakes, and this may cause significantly different behavior.

**Response:**

**All mines are unique and their specific character (geology, mineralogy, hydrology, and topography) must be carefully considered. It is true that there was extensive treatability testing at many of these mines. Experiences at Gilt Edge, Island**